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USAARU REPORT NO. 68-2

IMPROVING HELICOPTER CONSPICUITY THROUGH THE USE OF PAINTED MAIN ROTOR BLADES

By

John K. Crosley, MAJ, MSC
Robert W. Bailey, LTC, MSC
M. S. Nix, Jr., MAJ, VC

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ABSTRACT

An in-flight study was conducted to determine the effect of four paint schemes, applied to the main rotor blades of UH-1D helicopters, upon helicopter conspicuity. Twenty-three observers made a total of 138 comparisons of paired aircraft. The preferred scheme incorporated white, red-orange fluorescent, and black paints.

APPROVED: Robert W. Bailey

ROBERT W. BAILEY
LTC, MSC
Commanding

IMPROVING HELICOPTER CONSPICUITY THROUGH THE USE OF PAINTED MAIN ROTOR BLADES

I. INTRODUCTION

Mid-air collisions involving U. S. Army helicopters have increased in conjunction with the increase in numbers of aircraft being utilized within available airspace. Present mission requirements of U. S. Army Aviation dictate a necessity for more pilots and more aircraft. Limited airspace availability combined with increased aircraft usage demand more efficient methods for the avoidance of mid-air collisions.

Correspondence from Department of the Army, Army Concept Team in Vietnam requested that USAARU initiate a project designed to reduce mid-air collisions. Specifically, ACTIV indicated that one of the primary accident-producing situations concerned daytime landings in confined, dusty areas. Helicopter downwash from lead aircraft often creates a "dust storm" which partially or completely hides the airframe and main rotor blades of lead aircraft from the view of follow-on aircraft landing in the same area. This loss in visibility appears to be the primary cause of aircraft collision due to mixing rotor blades.

There are essentially three control methods that can be employed to help prevent mid-air collisions. Training, enforcement of proper procedures, etc., can be supplemented with the following control methods:

a. Complete air traffic control, e. g. instrument flight rules and radar necessary for complete control of airspace;

b. Complex, aircraft-mounted electronic equipment designed to warn of the presence of other aircraft within a specified distance; and

c. Visual warning.

Consideration of these control methods resulted in the selection of visual warning as the most practical and timely approach to the problem. Some of the prime considerations in this choice were the response time necessary to generate recommendations, availability of equipment, state of the art, and practicality of application that could be implemented in a relatively short time with a minimum of expense and complexity.

Visual warning for daytime use can be accomplished by exterior lighting mounted on the aircraft, and/or paint applied to the exterior of the aircraft. A review of the potential advantages and disadvantages of these methods indicated that each offered distinct possibilities. Therefore, it was decided to pursue in-flight research in these two areas.

This preliminary report outlines the research associated with the testing of paint and paint schemes derived to improve the daytime visibility of the helicopter. A study dealing with the application of exterior lighting to the helicopter is presently being conducted and will be reported at a later date.

The primary visual variables considered in this study have been described by Wulfeck, Weisz, and Raben[1]. These are: "variations of image position on the retina, light discriminations, spatial discriminations and temporal discriminations". In order to obtain maximum visual performance, engineering changes consonant with these visual variables were considered. For example, the selection of color, brightness, and pattern on the rotor were determined after due consideration of the effects of each upon visual performance.

This project was designed to determine the following:

1. Is there a difference in conspicuity between four paint schemes (incorporating six paints) applied to helicopter main rotor blades?

2. Can both pilots and non-pilots (co-pilots and jump-seal occupants) be treated as though drawn from equally distributed populations?

In view of mission requirements, the improvement of aircraft visibility as viewed from above was the primary consideration. The main rotor blade visibility is extremely poor unless the observer is directly beneath the aircraft. This position of viewing from below the aircraft provides maximum contrast of the dark blade against the bright sky. On the other hand, viewing a dark blade against

a dark background, as is often the case when viewing from above, decreases the already poor visibility to the point that it becomes the suspect cause of these rotor mixing crashes.

Previous reports dealing with paints and aircraft visibility (Malone, Sexton, and Farnsworth[2]; Malone[3]; Applied Psychology Corporation[4]; Lazo[5]; Lazo and Bosee[6]; and Middleton[7]) indicated that the use of paints could significantly improve aircraft visibility.

Lazo[5] notes seven major factors affecting conspicuity of fixed wing aircraft propellers. These are:

1. Color (hue and chroma) contrast within the blade color scheme;

2. Color (hue and chroma) contrast between the blade scheme and the backgrounds against which this colored blade is viewed;

3. Brightness contrast within the blade color scheme;

4. Brightness contrast between the blade scheme and the backgrounds against which this colored blade is viewed;

5. The patterning of the various colors on the blade;

6. The rotational speed of the blades; and

7. The size and number of the blades.

It was our opinion that these factors were equally applicable to the helicopter main rotor blade. Consideration of each of the factors and the visual parameters cited earlier resulted in the development of several main rotor paint schemes that "a priori" could be predicted to increase the visual performance in this situation.

Paints

In the choice of paints to be used, it was decided to include those already tested and selected by Lazo[5]. These were: Yellow-Orange AN color #506, Bright Red AN color #619, Specular White AN color #511, and Black AN color #604. The nomenclature for these paints as specified in the Federal Stock Catalog is as follows:

Red, Gloss (Insignia), Color No. 11136, Lacquer, FSN 8010-251-6503

Black, Lusterless, Color No. 37038, Lacquer, FSN 8010-687-3636

White, Gloss (Insignia), Color No. 17875, Lacquer, FSN 8010-297-2095

Yellow-Orange, Gloss, Color No. 13538, Lacquer, FSN 8010-248-2838

As a result of the conclusion of a study by the Applied Psychology Corporation[4] that, "---------- all things considered, the Federal Aviation Agency should encourage the use of fluorescent paint or films for their conspicuity value in close-range and intermediate-range situations ----------", it was decided to include a fluorescent paint, and a lusterless red paint in the comparative evaluation. These were:

Red-Orange Fluorescent ("Day-Glo"), Color No. 633, FSN 8010-684-8960

Red, Lusterless, (Bright), Color No. 31136, Lacquer, FSN 8010-042-3922

Aircraft

Four UH-1 D helicopters with 48-foot main rotor blades were chosen to be painted in the following manner (beginning with the blade tip):

Aircraft I. White (3 feet), Red, Gloss (3 feet), White (3 feet), Black (12 feet), Red, Gloss (3 feet).

Aircraft II. White (3 feet), Red, Lusterless (3 feet), White (3 feet), Black (12 feet), Red, Lusterless (3 feet).

Aircraft III. White (3 feet), Yellow, Gloss (3 feet), White (3 feet), Black (12 feet), Yellow, Gloss (3 feet).

Aircraft IV. White (3 feet), Red-Orange "Day-Glo" (3 feet), White (3 feet), Black (12 feet), Red-Orange "Day-Glo" (3 feet).

Two non-painted UH-1 helicopters were utilized to carry observers. These were equipped with two additional jump seats located immediately behind the pilot and co-pilot. A third non-painted helicopter served as a reserve in

case of mechanical difficulty with one of the observer craft.

Personnel

A total of twenty-three UH-1 rated pilots served as subjects. All personnel were briefed the morning of the test. At that time they were each given a number and a master sheet explaining what (by number) their particular function was to be at each stage of the test.

Test Procedure

The test aircraft were programmed for presentation in pairs to the observers. Their alignment was randomized to minimize biasing. The observer aircraft each contained four observers: the pilot, co-pilot, and two jump-seat occupants. After comparing each pair of aircraft, each observer was given a sheet of paper with a right and left circle representing aircraft. The observer indicated, by marking the appropriate circle, which aircraft he felt was most conspicuous. Since this was a "forced choice" type response, no allowance was made for indecision. The observations were made while two adjacent test helicopters hovered over an area especially chosen and prepared to simulate a dusty combat landing zone. Upon completion of the observation, the two test helicopters and the observation helicopter left their position and were replaced by the remaining two test and one observation craft. Following their observations, the two observation helicopters then exchanged positions and repeated the procedure. Next, the test aircraft switched positions and the entire process was repeated. A third set of presentations completed the series for this group of eight observers. At this point the personnel were rotated with eight from the test aircraft replacing those subjects who had previously acted as observers. These expended observers then became either pilot, co-pilot or passenger in the test aircraft. In this manner, a total of three series gave each of the twenty-three subjects an opportunity to act as an observer while occupying either the pilot, co-pilot or jump-seat position of the observer helicopter.

Radio communication from the ground was achieved via a jeep-mounted FM radio. However, the detailed instruction sheet plus the presence of a USAARU representative in each observer aircraft proved to be sufficient for control purposes.

III. RESULTS

A total of 138 observations were made. Each color combination could have been chosen 69 times. Based on chance alone (50%), each color would have been chosen 34.5 times. The following table indicates the observed frequency and the percentage of trials that each color was preferred:

	Color	"Day-Glo"	Yellow-Orange	Red (Lusterless)	Red (Gloss)
(a)	Observed Frequency	52	39	26	21
(b)	Expected Frequency based on Chance Alone (50%)	34.5	34.5	34.5	34.5
(c)	Total Possible Times Chosen	69	69	69	69
(d)	Percent of Trials on Which Preferred (a ÷ c)	75%	57%	38%	30%

A chi-square analysis of the observed frequencies of preferred choices of all four of the rotor blades resulted in a significant overall difference: X^2 obt. = 16.84, $p \leq .001$. Thus, the rotor blades differed from one another with respect to conspicuity. Since the blade painted with "Day-Glo" was preferred more often than any other blade (75%, the ratio of the number of observed

preferences for that blade), it is the most conspicuous blade.

A chi-square analysis of the frequency of choices for pilots and non-pilots (co-pilots and jump-seat occupants) showed no significant overall difference between the two groups (X^2 obt. = 2.05, $p \leq .05$). Thus the hypothesis that pilots and non-pilots are drawn from the same population cannot be rejected.

IV. DISCUSSION

This was the first known in-flight test of this type performed on rotor blade paint schemes of helicopters. The choice of colors was based upon contrast-producing capability and a priori pre-test evaluation of their effect upon the visual variables identified. The test was conducted to simulate, as nearly as possible, the dusty landing conditions often encountered in combat.

The results of the test indicate that further testing would be highly desirable. Increased aircraft visibility obtained through the use of painted rotor blades was deemed to have direct application in other than combat landing situations. This increase in helicopter conspicuity is especially desirable where high density areas exist. The reduced silhouette associated with the smaller models of helicopters, e. g. the TH-13T, often makes their presence extremely difficult to detect. Increased visibility of the rotor system, changing an invisible blur to a solid disk of contrasting color, is an effective solution to this detection problem.

The results of this study, though valuable, indicate a need for further investigation to clarify certain aspects of the problem. Specifically, these are:

1. Is there a statistically significant difference in the conspicuity of painted rotor blades as compared with non-painted?

2. Observations should also be conducted while the test helicopters fly over various types of terrain. This would insure the choice of a color combination which would maximally contrast with terrain features overflown during normal aircraft operation.

3. The area of the blade painted black in the tested schemes should be reduced somewhat, and the colored areas expanded to increase the contrast and brightness effects.

4. The smaller helicopters, TH-13T and TH-55A for example, present an extremely low silhouette, yet account for a large portion of the U. S. Army training fleet. What would be the effect of painting this smaller blade towards improving the conspicuity of these aircraft?

V. SUMMARY

A study was conducted to determine the effect of four different paint schemes, applied to the main rotor blades of UH-1 D helicopters, upon conspicuity. Twenty-three observers made a total of 138 observations. A chi-square analysis of the observed frequencies of preferred choices of all four of the rotor blades resulted in a significant ($p \leq .001$) overall difference. The blade painted with the combination of white, red-orange fluorescent ("Day-Glo") and black was the dominant preference and is thus considered the most conspicuous color scheme of the four evaluated. The ratio of the number of observed preferences divided by the number of possible preferences for this particular blade was 75 percent.

This test has indicated the possibility of employing painted rotor blades to improve helicopter conspicuity in areas other than the combat landing mode for which it was originally designed.

Results indicate the necessity for further testing to clarify specific problems associated with helicopter visibility.

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